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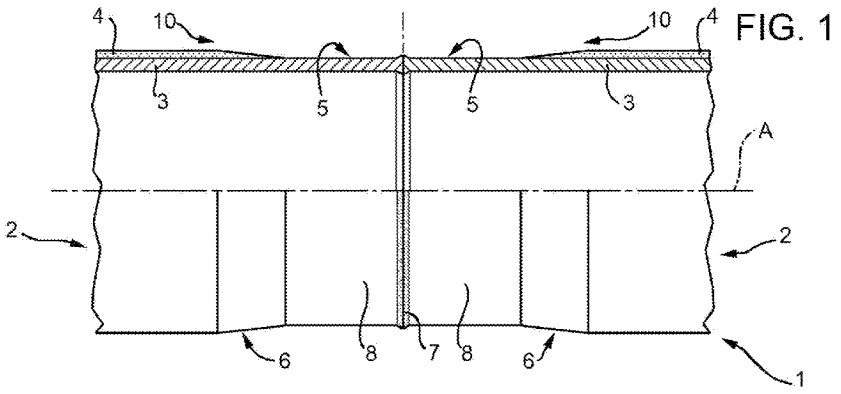

FIG. 1

(57) Abstract: An apparatus (12) for coating pipelines, in particular for coating a cutback (8) along a pipeline (1), having: a frame (13), which extends along a given axis (Al) and is fixable with respect to the pipeline (1) so as to arrange the given axis (Al) parallel to the longitudinal axis (A) of the pipeline (1); a carriage (14), which is supported by the frame (13), is movable along the given axis (Al) with respect to the frame (13), and is configured for supporting a heater (15) and an applicator (16); an actuator (17) configured for advancing the carriage (14) along the given axis (Al); and a control unit (18) for selecting a travel distance for the carriage (14) from a plurality of travel distances.

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"APPARATUS AND METHOD FOR COATING PIPELINES"

TECHNICAL FIELD

The present invention relates to an apparatus for coating pipelines.

In particular, the present invention relates to an apparatus for heating a cutback (annular joint portion) and depositing a coating on the cutback of a pipeline for transporting hydrocarbons.

BACKGROUND ART

The pipes for transporting hydrocarbons are composed of pipe sections joined together to cover overall lengths in the order of hundreds of kilometres. The pipe sections have a unit length, generally 12 metres, and relatively large diameters of between 0.2 and 1.5 metres. Each pipe section comprises a steel cylinder, a coating in a polymer material that has the function of protecting the steel pipe, and a possible further coating in Gunite or concrete, the function of which is to weigh down the pipeline for underwater applications, or a further coating in an insulating material to thermally insulate the pipeline.

To allow welding the steel cylinders together, the opposite free ends of each pipe section have no coating. The pipe sections are joined to one another both in land installations to form lengths of pipe that are multiples of the unit length, and in laying vessels, where the pipe sections, of unit length or multiples thereof, are joined to lengths of pipe already joined to other lengths of pipe to form part of the underwater pipeline.

The joining operations envisage welding the steel cylinders, usually in several welding passes, and restoring the coating.

Once a welding bead ring has been completed between two steel cylinders, an uncoated cutback straddles the weld. The cutback is basically the annular joint portion defined by the free ends of the pipe sections and extending axially between two end edges of the coating, and must be covered by a protective coating.

Application of the protective coating on the cutback is known as field joint coating and, in general, envisages coating the cutback with three layers designed to ensure protection of the steel cylinders and the adhesion of these layers thereto. Field joint coating on the cutback envisages: heating, by induction for example, the cutback up to a temperature in the range 160-250°C; coating the cutback with a fusion bonded epoxy (FBE) resin that forms, on contact with the cutback, a first, relatively thin layer, known as the primer; spraying on the cutback, on top of the primer, a modified copolymer with an adhesive function that forms, in contact with the primer, a second relatively thin layer; and applying a third coat, generally known as the top coat.

In general, the first layer, or primer, is applied by means of a cylindrical inductor, which is placed around the cutback and structured like a clamp, and an applicator that is movable with respect to the outer surface of the cutback to apply a polymer material on the cutback. Some examples of apparatuses for coating pipelines that enable heating the pipeline with a cylindrical inductor and applying the first layer in quick succession are described in documents WO 2009/024,755 and US 4,595,607. Known apparatuses of the above-indicated type suffer from the drawback of not being adaptable to cutbacks of different length and, in consequence, for design reasons it is often necessary to have a plurality of coating apparatuses.

DISCLOSURE OF INVENTION

The object of the present invention is to provide an apparatus

for coating a pipeline that is devoid of the drawbacks of the known art.

In accordance with the present invention, an apparatus for coating pipelines is provided, in particular for coating cutbacks along a pipeline, the apparatus comprising:
- a frame, which extends along a given axis and is fixable with respect to the pipeline so as to arrange the given axis parallel to the longitudinal axis of the pipeline;
- at least one carriage, which is supported by the frame, is movable along the given axis with respect to the frame, and is configured for supporting a heater and an applicator;
- at least a first actuator configured for advancing the carriage along the given axis; and
- a control unit for selecting a travel distance for the carriage from a plurality of travel distances.

With the present invention, the heater and the applicator can be advanced along the longitudinal axis of the pipeline and implement a kind of scanning of the outer surface of the pipeline and for a travel distance that can be selected as needed.

In particular, the frame comprises a first frame portion fixable with respect to the pipeline; a second frame portion supported in a rotatable manner about the given axis by the first frame portion; and a second actuator for rotating the second frame portion with respect to the first frame portion about the given axis.

The rotation of the second frame portion with respect to the first frame portion enables using non-annular heaters and applicators, which thus perform a scan of the cutback in both the axial direction and the annular direction.

In particular, the first frame portion comprises two first

opposing heads connected to one another, and configured for being arranged around, and clamped to, the pipeline; in particular, each head comprises a fixed part and an arm hinged to the fixed part and selectively movable between an open and a closed position.

The clamping of the first frame portion on the pipeline enables handling the movements of the heater and the applicator with reference to the pipeline.

In particular, the first frame portion comprises a support structure connected to the two first heads and configured to keep the first heads a given distance apart.

This distance is selected so as to contain all the possible travel distances of the carriage.

In particular, the first frame portion comprises a coupling for a manipulator.

Due to this solution, the movement of the apparatus is very quick and accurate.

In particular, the second frame portion comprises two second opposing heads connected to one another by guides, which are slidably engaged by the carriage.

The guides have the dual function of guiding the carriage and supporting the second heads at a given distance apart.

In particular, each second head is shaped like an open ring, the opening being such as to enable fitting the frame around the pipeline.

In practice, the second frame portion does not obstruct fitting the frame around the pipeline.

In particular, the carriage comprises: a main body; a first mounting member configured to support a heater or an applicator; and a second mounting member configured to support an applicator or a heater.

The carriage supports a heater and an applicator in an independent manner.

In particular, the first mounting member and/or the second mounting member are mounted in a selectively movable manner along the main body in a radial direction with respect to the given axis.

Adjustment of the mounting members is independent.

Advantageously, the first actuator comprises a screw nut mounted on the carriage and a threaded rod supported by the frame.

A further object of the present invention is to provide a method free of the drawbacks of the known art.

In accordance with the present invention, a method is provided for coating pipelines, in particular for coating cutbacks along a pipeline, the method comprising the steps of:
- fixing a frame extending along a given axis with the respect to the pipeline so as to arrange the given axis parallel to the longitudinal axis of the pipeline;
- advancing a heater and an applicator in quick succession along the frame parallel to the given axis (A1); and
- selecting the travel distance for the heater and the applicator from a plurality of travel distances.

With the present invention, it is possible to select the size of the area on which to apply the coating as needed.

In particular, the method provides for rotating the heater and/or the applicator about the given axis along a given path.

In this way, heaters and applicators that do not extend around the pipeline can also be used.

In particular, the method provides for fitting the frame around the pipeline in a radial direction with respect to the longitudinal axis of the pipeline.

The fitting and removal of the frame in the radial direction are facilitated when heaters and applicators that extend around the pipeline are not used, as their disassembly is not required.

In particular, the method provides for clamping the frame on the pipeline. In this way, it is possible to accurately control the position of the heater and the applicator with respect to the pipeline.

In particular, the method provides for adjusting the position of the heater with respect to frame in a radial direction with respect to the given axis.

This adjustment allows choosing the distance that enables achieving an efficient heating treatment. In addition, it allows adapting the position of the heater to pipelines of different diameters.

In particular, the method provides for adjusting the position of the applicator with respect to the frame in a radial direction with respect to the given axis.

This adjustment allows choosing the distance that enables achieving an efficient application treatment and adapting the

position of the applicator for different diameters.

BRIEF DESCRIPTION OF THE DRAWINGS

Further characteristics and advantages of the present invention will become clear from the description that follows of its preferred embodiments, with reference to the figures in the accompanying drawings, in which:

- Figure 1 is a side elevation view, with parts in section and parts removed for clarity, of a pipeline;
- Figure 2 is a side elevation view, with parts in section and parts removed for clarity, of the pipeline;
- Figure 3 is a schematic side elevation view, with parts in section and parts removed for clarity, of the pipeline in Figure 1 and of an apparatus for coating the pipeline;
- Figure 4 is a perspective view, with parts removed for clarity, of an apparatus for coating the pipeline in Figure 1 in accordance with a variant of the present invention;
- Figure 5 is a plan view, with parts removed for clarity, of a detail of the apparatus in Figure 4;
- Figure 6 is a perspective view, with parts in section and parts removed for clarity, of a variant of the apparatus in Figure 4;
- Figure 7 is a sectional view, with parts in section and parts removed for clarity, of a detail of the apparatus in Figure 4; and
- Figure 8 is a perspective view, with parts removed for clarity, of a detail of the apparatus in Figure 4.

BEST MODE FOR CARRYING OUT THE INVENTION

THE PIPELINE

In Figures 1 and 2, reference numeral 1 indicates a pipeline as a whole, which extends along a longitudinal axis A and comprises two pipe sections 2 aligned along the longitudinal axis A. Each pipe section 2 comprises a metal cylinder 3 and a polymer coating 4, usually in polyethylene or polypropylene,

which is placed in contact with the metal cylinder 3 and has the function of protecting the metal cylinder 3 from corrosion. Each pipe section 2 has two opposite free ends 5 (only one of which is shown in Figure 1) without the coating 4, and has a bevel 6 on each free end 5. Two successive pipe sections 2 aligned along the longitudinal axis A are arranged with the free ends 5 facing each other and are welded, possibly in several welding passes, so as to form an annular welding bead 7 between the two pipe sections 2. The two welded pipe sections 2 define a cutback 8, which extends along the longitudinal axis A between the two successive bevels 6 of the coating 4 and comprises the annular welding bead 7. The pipeline 1 is formed by joining the pipe sections 2. With regard to this description, the term pipeline 1 also means the pipeline in the construction phase, formed, for example, by just two pipe sections 2 joined together.

In addition to the welding of the metal cylinders 3, the joining operation on the pipe sections 2 also provides for forming a coating that connects the pre-existing coatings 4 such that the coating of the pipeline is uninterrupted. This operation envisages forming a protective layer 9 around the cutback 8 and around two end portions 10 of the coating 4 and making the protective layer 9 adhere to the cutback 8 and the end portions 10 of the coatings 4.

Application of the protective layer 9 usually requires preliminary operations of preparing the cutback 8 and the end portions 10 to favour adhesion of the protective layer 9. These operations consist in cleaning, by sandblasting for example, and heating, by induction for example, the cutback 8, and in depositing a thin layer 11 of polymer powder material, a fusion bonded epoxy (FBE) resin for example, on the still hot metal cylinder 3 to form the primer. It is possible to spray a layer of adhesive between layer 11 and the protective layer 9.

The protective layer 9 has a thickness of between 0.1 and 7 mm, and is formed by a polymer, preferably polyolefins, and preferably CMPE or CMPP.

The protective layer 9 has a width wider than the width of the cutback 8 (measured along the longitudinal axis A) so as to overlap the coatings 4 at the respective end portions 10, and a length such as to ensure covering the perimeter of the cutback 8, including overlapping of the end edges of the protective layer 9. The pipeline 1 produced in this manner is suitable for various types of usage, such as underwater ones for example, for the transport of hydrocarbons across sea areas.

In Figure 3, reference numeral 12 indicates an apparatus for heating the cutback 8 and applying polymer powder material on the cutback 8.

The joining operations described for making the pipeline 1 are performed both in on-land plants and on laying vessels.

APPARATUS FOR APPLYING THE FIRST LAYER

With reference to Figure 3, the apparatus 12 is configured to coat the cutback 8 with a first layer 11 (Figure 2). In greater detail, the apparatus 12 is configured to perform work cycles, each of which envisages: coupling the apparatus 12 to the pipeline 1; heating the cutback 8 to a temperature between 170°C and 270°C; applying, in quick succession or simultaneously, the polymer powder material on the still hot cutback 8; and releasing the pipeline 1. In this description the adjective "axial" refers to the longitudinal axis A of the pipeline 1.

The apparatus 12 is configured for being mounted on a manipulator, not shown in the accompanying figures, and

comprises: a frame 13, which extends along an axis A1 and is configured for being fixed with respect to the pipeline 1, so as to arrange axis A1 parallel to the longitudinal axis A of the pipeline 1; and two carriages 14, which are supported by the frame 13 and are movable along axis A1 with respect to the frame 13. Each carriage 14 is configured to support a heater 15 and an applicator 16. In the case shown, the two applicators 16 have an annular shape, are supported by both the carriages 14, and are arranged on opposite sides with respect to the heaters 15.

The apparatus 12 comprises an actuator 17 configured to advance the carriage 14 along axis A1, and a control unit 18 configured to allow the selection of a travel distance for the carriage 14 from a plurality of travel distances.

The frame 13 comprises: a frame portion 19 configured for being fixed with respect to the pipeline 1; a frame portion 20 supported in a rotatable manner about the axis A1 of the frame portion 19; and an actuator 21 to rotate the frame portion 20 with respect to the frame portion 19 about axis A1.

In practice, the carriage 14 is movable along axis A1 and can rotate about axis A1.

The frame portion 19 comprises two opposing heads 22 connected to each other and configured for being arranged around, and clamped to, the pipeline 1.

The apparatus 12 in Figure 4 differs from that in Figure 3 in the relative positions of the heaters 15 and the applicators 16, while the reference numerals employed naturally refer to both embodiments.

With reference to Figure 4, the applicators 16 are positioned alongside one another, while the heaters 15 are arranged on

opposite sides with respect to the applicators 16 in the axial direction.

Each head 22 is shaped like an open ring and comprises a U-shaped fixed part 23 and an arm 24 selectively movable between an open and a closed position. The fixed part 23 and the arm 24 comprise spacers 25 configured for being arranged on opposite sides of the cutback 8 so as to place axis A1 substantially coaxial with the longitudinal axis A (Figure 3).

The frame portion 19 comprises a support structure 26, which is connected to the heads 22 and is configured to keep the heads 22 a given distance apart. The maximum travel distance of the carriage 14 is determined by the distance between the heads 22. The frame portion 19 comprises a coupling 27 for the manipulator 24 and, in particular, the coupling 27 is arranged along the support structure 26.

Frame portion 20 comprises two opposed heads 28 connected to one another by guides 29 (Figure 4), which in the case shown are rods slidably engaged by the carriage 14.

Each head 28 is formed by an open ring, in which the opening of the ring is larger than the diameter of the pipeline 1 (Figure 5). The carriage 14 comprises: a main body 30; a mounting member 31 configured to support a heater 15; and a mounting member 32 configured to support an applicator 16.

The mounting member 31 is mounted in a selectively movable manner along the main body 30 in a radial direction for adjusting the distance of the heater 15 from axis A1. In particular, the main body 30 is substantially defined by a plate and the mounting member 31 is coupled in a sliding manner along this plate and to an actuator 33 for controlling the movement of the mounting member 31.

In accordance with a variant of the present invention that is not shown, both of the mounting members are movable in a radial direction with respect to the main body.

The actuator 17 comprises: a nut 34 mounted on the carriage 14; a threaded bar 35 parallel to axis A1 and supported by the frame 13, in particular, by the heads 28; and a motor 36 for turning the nut 34.

With reference to Figure 5, the actuator 21 comprises: an open crown wheel 37 mounted on a head 28; a sprocket wheel 38, which is mounted on the head 22 adjacent to the crown wheel 37 and meshes with the crown wheel 37; and a motor 39 for selectively rotating the sprocket wheel 38.

With reference to Figure 4, the actuator 33 is a linear actuator that, in the case shown, is defined by a hydraulic cylinder.

The heater 15 is a high-frequency electric inductor supplied with alternating current at a high frequency, in particular between 15,000 and 40,000 Hz, more specifically between 20,000 and 30,000 Hz. In the case shown in Figure 4, the heater 15 has a plate-like shape and comprises a magnetic circuit 40 and a coil 41 of electrically conductive material supported by the magnetic circuit 40.

In accordance with the variant in Figure 6, each heater 15 is replaced with a heater 42 having a toroidal shape and comprising an annular magnetic circuit 43 and at least one coil 44 of electrically conductive material supported by the magnetic circuit 43.

With reference to Figure 7, each applicator 16 comprises an annular body 45 and a mixing chamber 46, which is formed inside the annular body 45 and is configured to enable the

mixing of a polymer powder and air, and the distribution of the mixture in the mixing chamber 46.

With reference to Figure 8, the annular body 45 is formed by at least two complementary parts 47 and 48 that enable mounting the applicator 16 around the pipeline 1.

With reference to Figure 7, the annular body 45 comprises an annular slit 49 for connecting the mixing chamber 46 to the outside and forming a film of polymer powder directed towards the pipeline 1.

A hose 50 (Figure 8) is connected to the mixing chamber 46 for feeding polymer powder and air to the mixing chamber 46.

According to a variant not shown in the accompanying figures, the applicator is defined by a spray gun, i.e. a nozzle, the position of which is adjustable in the radial direction.

With reference to Figure 4, the control unit 18 is configured for setting and controlling the actuators 17, 21 and 33, the heaters 15 or 42 and the applicators 16. Actuator 17 determines the travel distance and translation speed of the carriage 14 along axis A1. Actuator 21 determines the travel distance and rotational speed of the carriage 14 about axis A1. Actuator 33 adjusts the distance between the mounting member 31 and axis A1. The power and frequency of the heaters 15 or 42 can be adjusted as a function of the position of the heaters 15 or 42 along axis A1 and the planned work cycle. Similarly, the flow of air and polymer powder through the applicators 16 is adjusted as a function of the work cycle.

The movement of the carriage 14 is determined by the composition of the translation of the carriage 14 along axis A1 and the rotation of the carriage 14 about axis A1. This composition can be created in a plurality of different

variants.

In accordance with the preferred embodiment of the invention, the apparatus 12 comprises two carriages 14, which are mounted on the same guides 29 and are arranged facing each other. Each carriage 14 is equipped with a heater 15 and an applicator 16. In particular, both of the carriages 14 support two applicators 16 on two facing sides.

Finally, it is obvious that variants can be made regarding the present invention with respect to the embodiments described with reference to the accompanying figures without departing from the scope of the claims.

In addition to the combination of annular applicators with plate heaters and annular applicators with annular heaters, the described apparatus enables combining plate heaters with spray guns and/or annular heaters with spray guns.

Furthermore, each carriage is able to independently support a respective heater and a respective applicator, and is able to move independently of the other carriage.

In accordance with a further variant, the apparatus comprises only one carriage having only one heater and only one applicator.

CLAIMS

1. An apparatus for coating pipelines, in particular for coating cutbacks along a pipeline, the apparatus (12) comprising:
- a frame (13), which extends along a given axis (A1) and is fixable with respect to the pipeline (1) so as to arrange the given axis (A1) parallel to the longitudinal axis (A) of the pipeline (1);
- at least one carriage (14), which is supported by the frame (13), is movable along the given axis (A1) with respect to the frame (13), and is configured for supporting a heater (15; 42) and an applicator (16);
- at least a first actuator (17) configured for advancing the carriage (14) along the given axis (A1); and
- a control unit (18) for selecting a travel distance for the carriage (14) from a plurality of travel distances.

2. The apparatus as claimed in Claim 1, wherein the frame (13) comprises a first frame portion (19) configured for being fixed with respect to the pipeline (1); a second frame portion (20) supported in a rotatable manner about the given axis (A1) by the first frame portion (19); and a second actuator (21) for rotating the second frame portion (20) with respect to the first frame portion (19) about the given axis (A1).

3. The apparatus as claimed in Claim 2, wherein the first frame portion (19) comprises two first opposing heads (22) connected to one another and configured for being arranged around, and clamped to, the pipeline (1); in particular, each head (22) comprises a fixed part (23) and an arm (24) hinged to the fixed part (23) and selectively movable between an open and a closed position.

4. The apparatus as claimed in Claim 3, wherein the first frame portion (19) comprises a support structure (26)

connected to the two first heads (22) and configured to keep the first heads (22) a given distance apart.

5. The apparatus as claimed in any one of claims 2 to 4, wherein the first frame portion (19) comprises a coupling (27) for a manipulator.

6. The apparatus as claimed in any one of claims 2 to 5, wherein the second frame portion (20) comprises two second opposing heads (28) connected to one another by guides (29), which are slidably engaged by the carriage (14).

7. The apparatus as claimed in claim 6, wherein each second head (28) is shaped like an open ring, the opening being such as to enable fitting the frame (13) around the pipeline (1).

8. The apparatus as claimed in any one of the foregoing claims, wherein the carriage (14) comprises a main body (30); a first mounting member (31) configured to support a heater (15; 42) or an applicator (16); and a second mounting member (32) configured to support an applicator (16) or a heater (15; 42).

9. The apparatus as claimed in claim 8, wherein the first mounting member (31) and/or the second mounting member (32) are mounted in a selectively movable manner along the main body (30) in a radial direction with respect to the given axis (A1).

10. The apparatus as claimed in any one of the foregoing claims, wherein the first actuator (17) comprises a nut (34) mounted on the carriage (14) and a threaded bar (35) supported by the frame (13).

11. The apparatus as claimed in any one of the foregoing claims, and comprising an induction heater (15; 42) supplied

with alternating current at a frequency, in particular, comprised between 15,000 and 40,000 Hz.

12. The apparatus as claimed in any one of the foregoing claims, and comprising a plate-shaped heater (15) comprising a magnetic circuit (40), and at least one coil (41) of electrically conductive material supported by the magnetic circuit (40).

13. The apparatus as claimed in any one of the foregoing claims, and comprising a toroid-shaped heater (42) comprising an annular magnetic circuit (43), and at least one coil (44) of electrically conductive material supported by the magnetic circuit (43).

14. The apparatus as claimed in any one of the foregoing claims, and comprising an applicator (16), which is mounted on the carriage (14), and comprises an annular body (45) and a mixing chamber (46), which is formed inside the annular body (45) and is configured to enable the mixing of a polymer powder and air, and the distribution of the mixture along the mixing chamber (46).

15. The apparatus as claimed in claim 14, wherein the annular body (45) is formed by at least two complementary parts (47, 48) movable between a closed and an open position so as to allow mounting the applicator (16) around the pipeline (1).

16. The apparatus as claimed in claim 14 or 15, wherein the annular body (45) comprises an annular slit (49) for connecting the mixing chamber (46) to the outside and forming a film of polymer powder.

17. The apparatus as claimed in any one of claims 14 to 16, wherein a hose (50) is connected to the mixing chamber (46) for feeding polymer powder and air to the mixing chamber (46).

18. The apparatus as claimed in any one of the foregoing claims, wherein the control unit (18) is configured for setting and controlling the travel distance of the carriage (14) and the operation and rest cycles of the heater (15; 42) and the applicator (16).

19. The apparatus as claimed in any one of the foregoing claims, and comprising two carriages (14), each carriage (14) being provided with one heater (15; 42) and one applicator (16).

20. The apparatus as claimed in claim 19, wherein the two carriages (14) support both heaters (15; 42) and/or applicators (16) on opposite sides of the given axis (A1).

21. A method for coating pipelines, in particular for coating cutbacks along a pipeline, the method comprising the steps of:
- fixing a frame (13) extending along a given axis (A1) with the respect to the pipeline (1) so as to arrange the given axis (A1) parallel to the longitudinal axis (A) of the pipeline (1);
- advancing a heater (15; 42) and an applicator (16) in quick succession along the frame (13) parallel to the given axis (A1); and
- selecting the travel distance for the heater (15; 42) and the applicator (16) from a plurality of travel distances.

22. The method as claimed in claim 21, and comprising the step of rotating the heater (15; 42) and/or the applicator (16) about the given axis (A1) along a given path.

23. The method as claimed in claim 21 or 22, comprising the step of fitting the frame (13) around the pipeline (1) in a radial direction with respect to the longitudinal axis (A) of the pipeline (1).

24. The method as claimed in any one of claims 21 to 23, and comprising the step of clamping the frame (13) to the pipeline (1).

25. The method as claimed in any one of claims 21 to 24, and comprising the step of adjusting the position of the heater (15; 42) with respect to frame (13) in a radial direction with respect to the given axis (A1).

26. The method as claimed in any one of claims 21 to 25, and comprising the step of adjusting the position of the applicator (16) with respect to the frame (13) in a radial direction with respect to the given axis (A1).

27. The method as claimed in any one of claims 21 to 26, wherein the heater (15; 42) is a high-frequency electric inductor, the method comprising the step of supplying the electric inductor with alternating current at a frequency, in particular, comprised between 15,000 and 40,000 Hz.

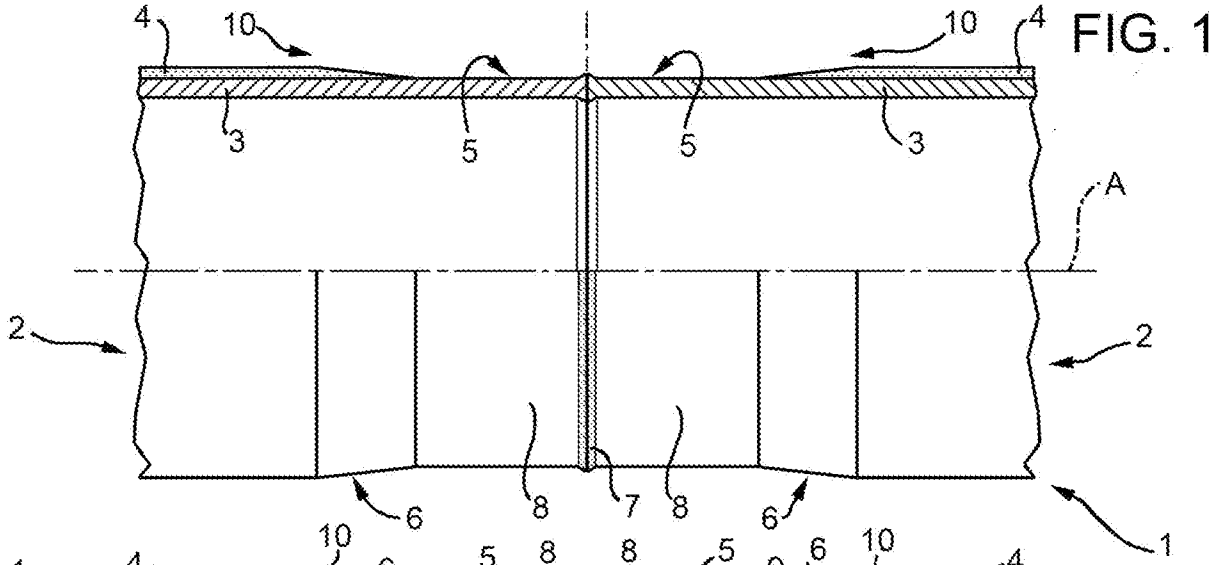

FIG. 1

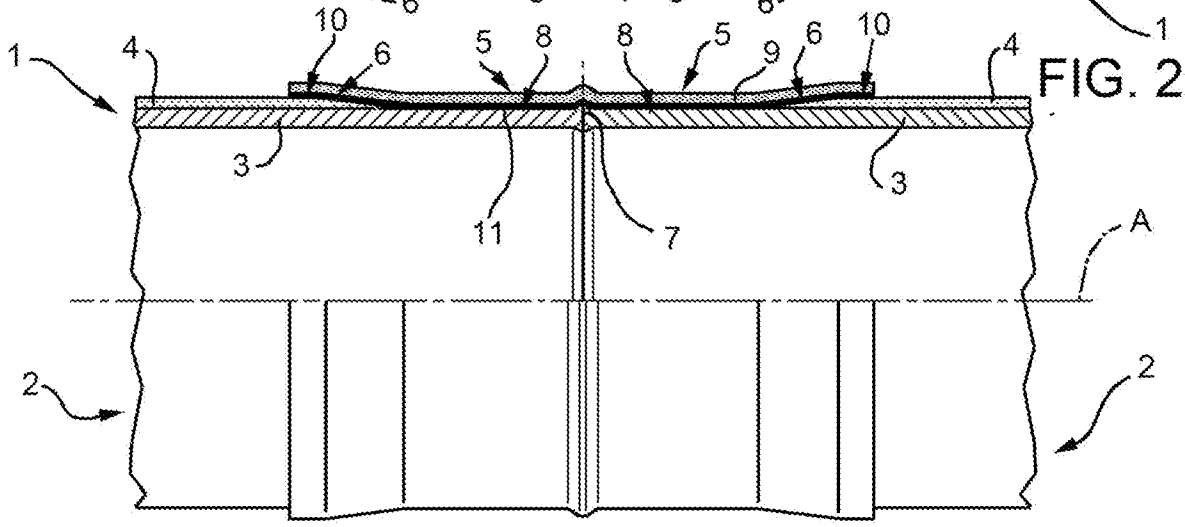

FIG. 2

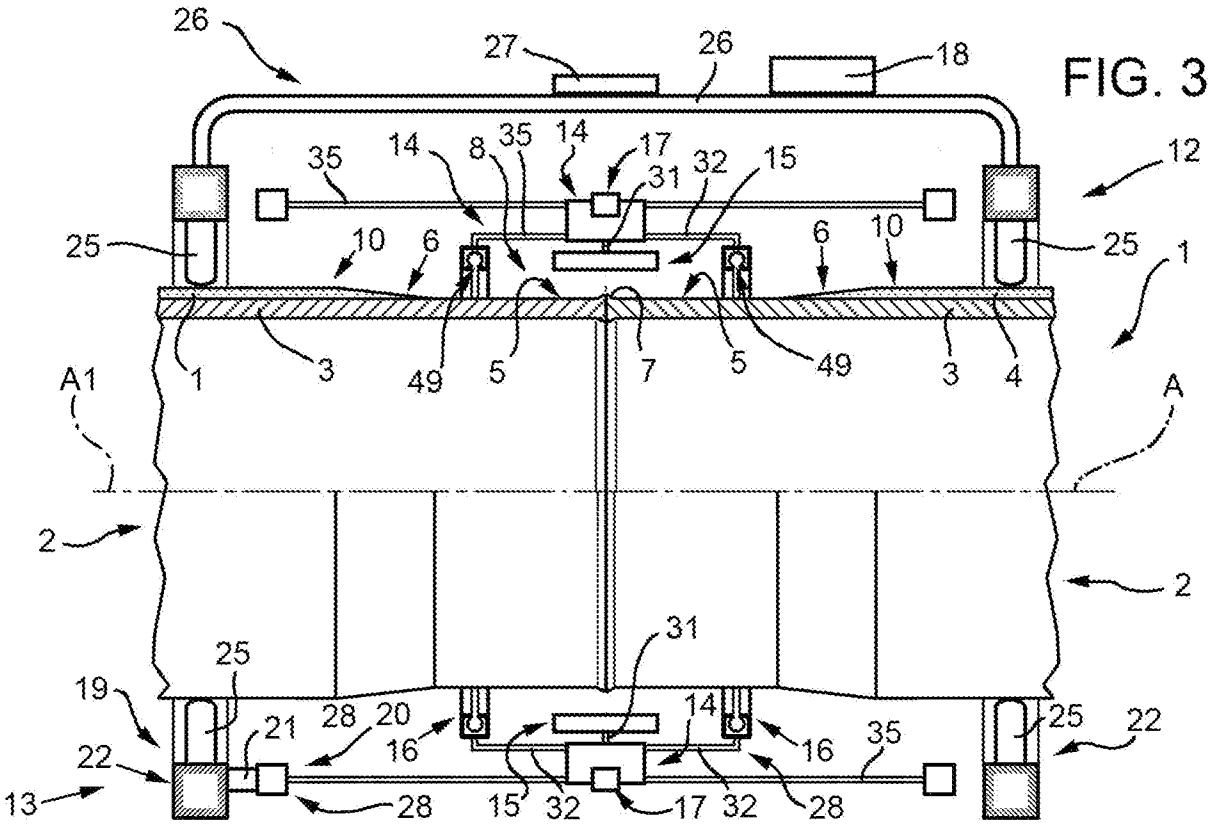

FIG. 3

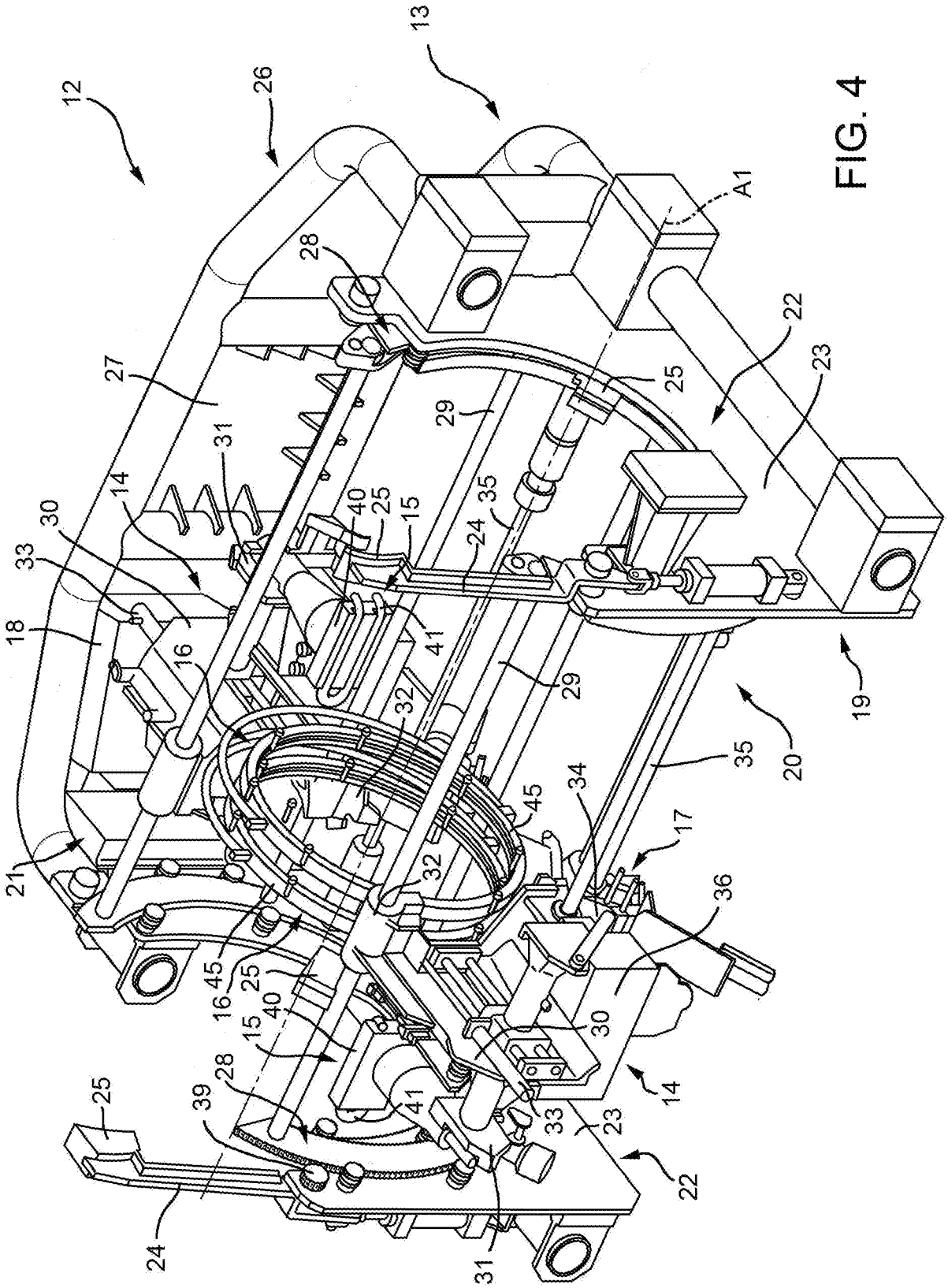
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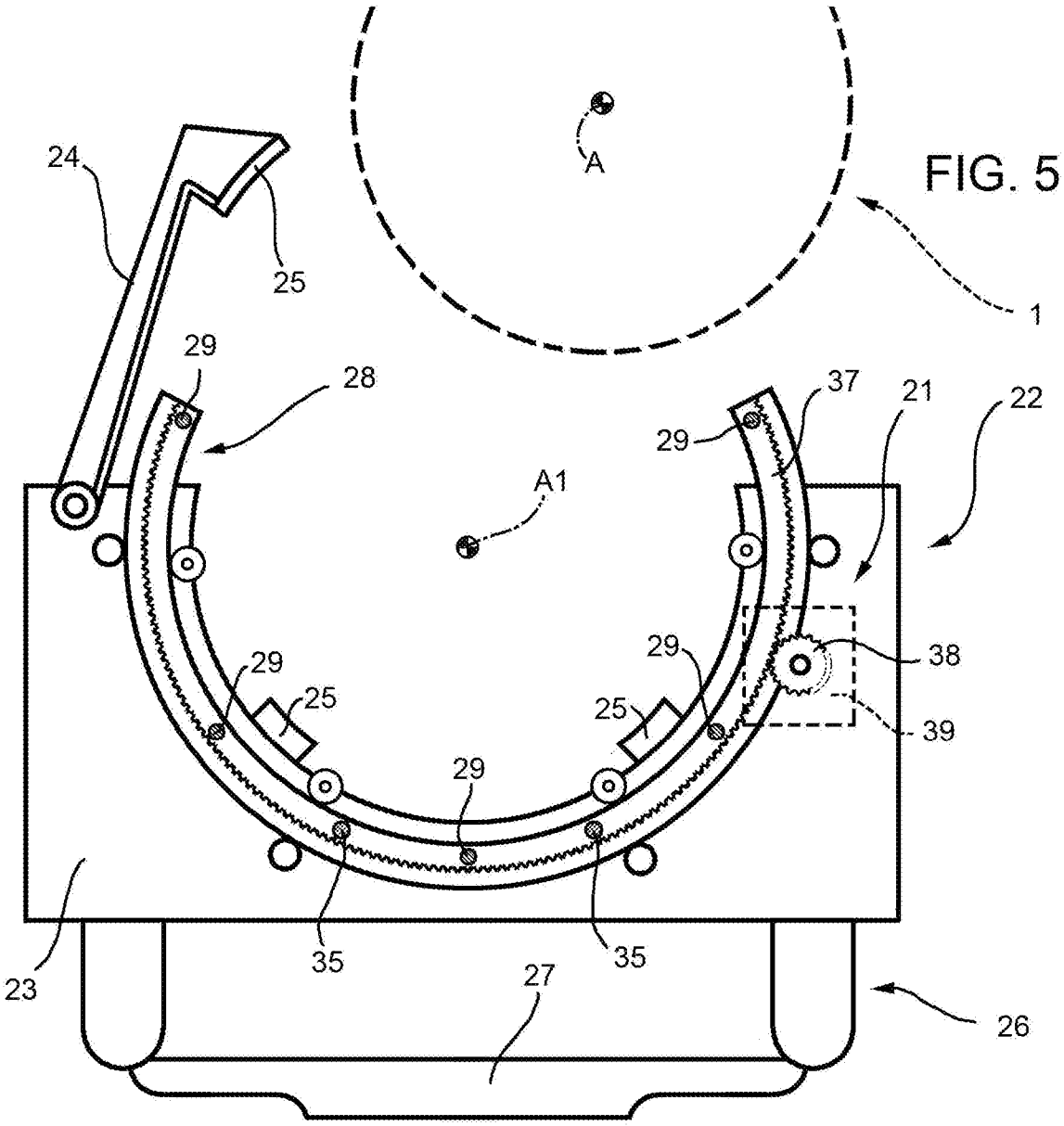
FIG. 4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A1
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FIG. 5

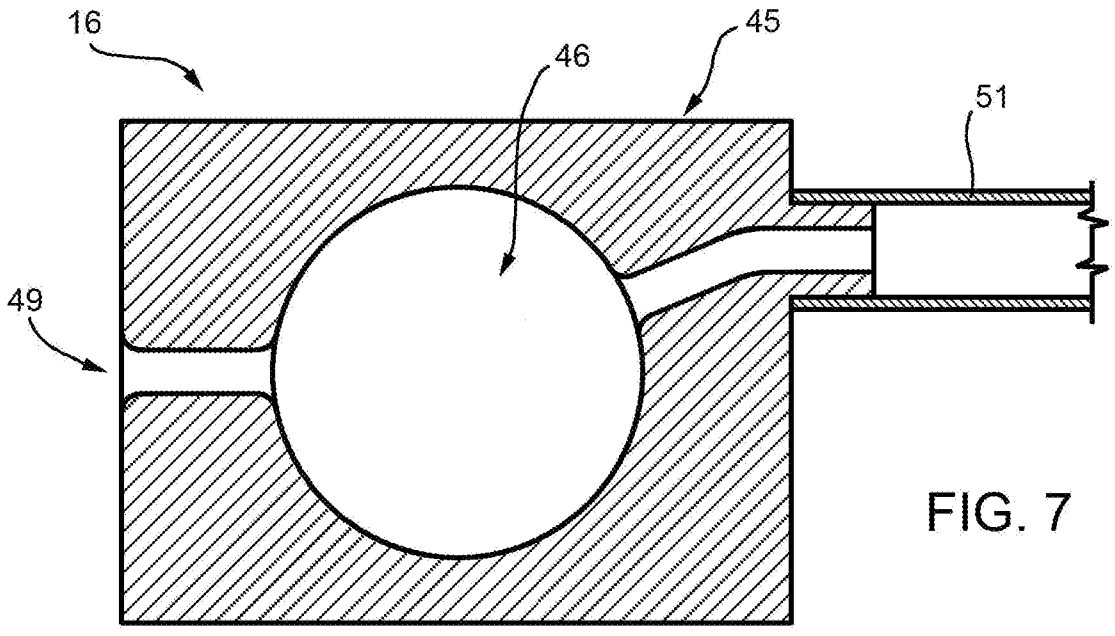
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FIG. 7

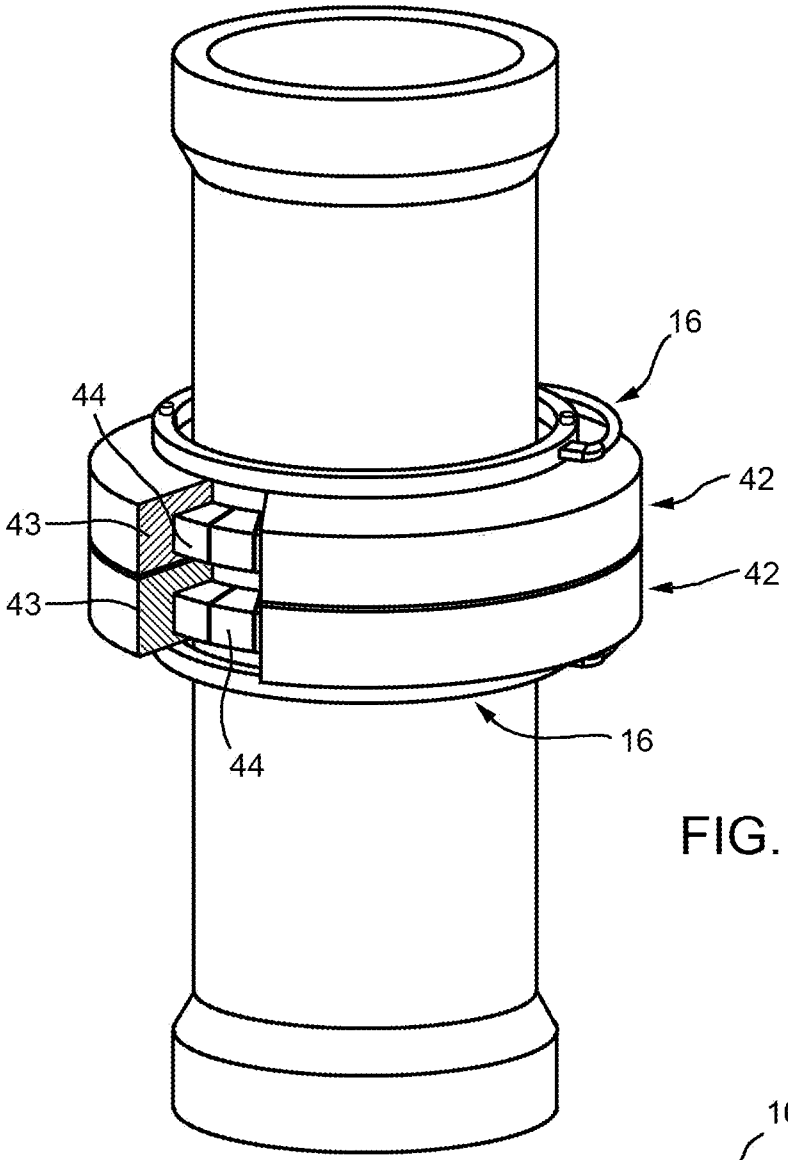

FIG. 6

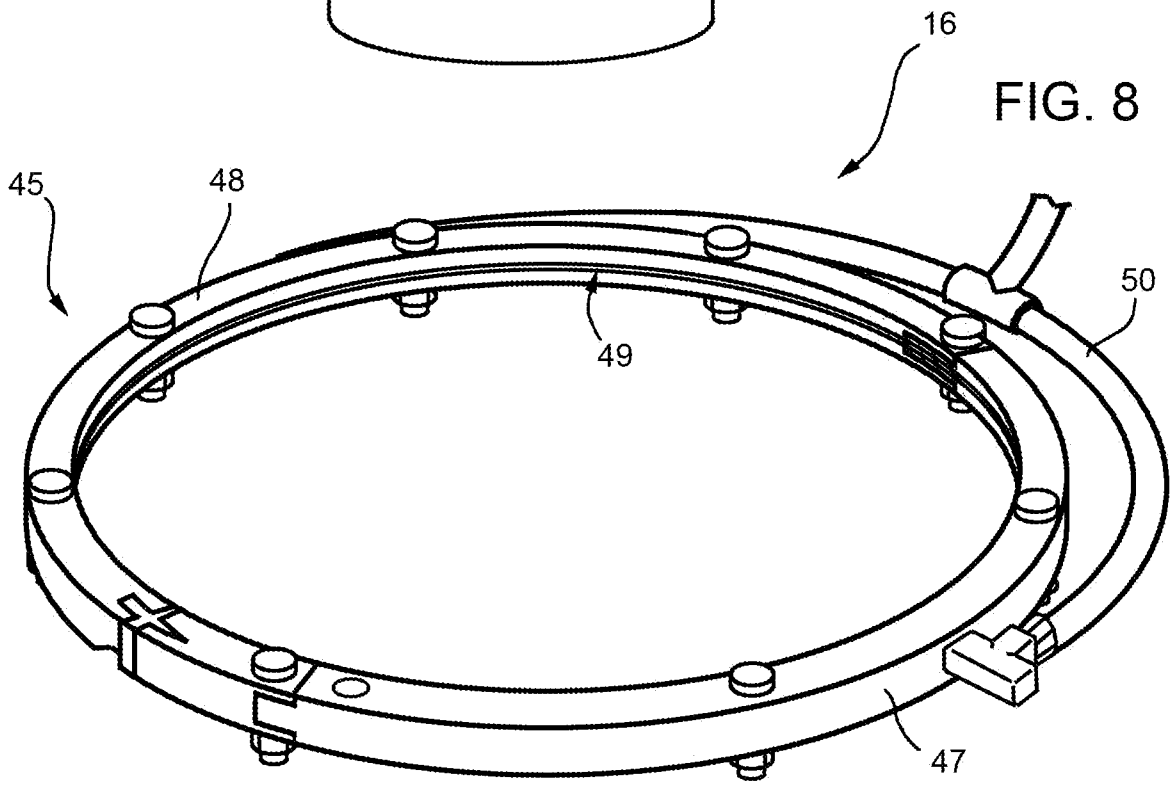

FIG. 8